RESEARCH HIGHLIGHT

April 2009

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Canada at the 2007 Solar Decathlon Competition

INTRODUCTION

This Research Highlight summarizes the experience of the only Canadian entry in the 2007 Solar Decathlon, *Lumen | Essence* (Figure 1) by Team Montréal. It provides a brief overview of the competition, Team Montréal's methodology, the *Lumen | Essence* project, and the final results of the competition.

Background

Launched in 2002, the Solar Decathlon is a biennial design-build-operate competition, sponsored by the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy. It challenges teams of college and university students from around the world to create a self-sufficient, solar-powered house that can be transported and reassembled at the Washington D.C. National Mall to form a "solar village" with other houses entered into the competition.

To compete, teams must provide a submission that explains their vision for designing and building an energy-efficient home that is powered exclusively by the sun and that can accommodate the lifestyle of an average modern couple. The submission must also show how the project will be integrated within the school's curriculum. Selected teams are granted core funding to help them get started and are expected to acquire additional support through partnerships with industry.

An important criterion for the Solar Decathlon homes is that they must be attractive and easy to live in. Throughout the competition, the decathletes must demonstrate that their homes can maintain a comfortable temperature, provide hot water and adequate lighting, power household appliances for cooking, cleaning and home electronics. In addition, these houses must generate enough surplus energy to power an electric vehicle that meets household transportation needs.

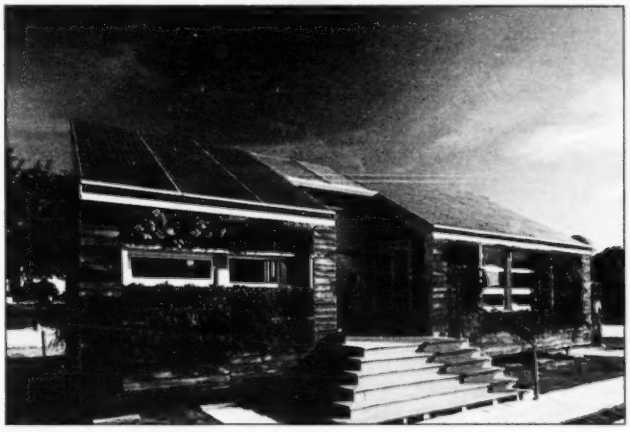


Figure 1 The *Lumen | Essence* House

The Solar Decathlon is an event at which the public is invited to observe the powerful combination of solar energy, energy efficiency, and the best in home design. The houses are open every day for public tours and are designed to show that solar energy can effectively meet and, in some cases, exceed household needs. The solar village also offers educational exhibits on energy efficiency and renewable energy, workshops for consumers and industry professionals, briefing sessions and "ask the experts" days where green-building specialists are on-site to answer any questions.

The 2007 competition was held from October 12 to 20 and featured twenty teams. Sixteen teams were from the United

States, and one team each from Germany, Spain and Puerto Rico. Team Montréal was the sole Canadian team to be selected for the competition.

About Team Montréal

Team Montréal was a consortium of approximately thirty students and three principal faculty advisors from École de Technologie Supérieure (ETS), la Faculté de l'aménagement de l'Université de Montréal, and the McGill University School of Architecture.

The three faculty advisors guided the team of students, monitored progress, and ensured the project was integrated within the curriculum at their respective institutions. An administrative council with various subcommittees comprised of the faculty advisors and student leaders was formed to manage logistics, make decisions regarding administration and initiatives to pursue, and sustain the vision of the project. The subcommittees, overseen by a student president, each represented a specific discipline or area of expertise:

- **Electrical:** responsible for solar energy production and all electrical systems.
- **Mechanical:** responsible for all mechanical systems (heating, ventilation and water systems).
- **Architecture:** responsible for designing a home that meets competition requirements.
- **Construction:** responsible for determining the building's structural elements and drawing plans and providing estimates for construction of the home.
- **Communications:** responsible for the team's web site, presentations, publicity, media relations, and project documentation.
- **Sponsors and fundraising:** responsible for project funding, finding partners, and carrying out fundraising activities.

Integrated Design Process

In an effort to bring together the different student backgrounds and dual languages and further improve the project concept, the team followed an integrated design process. A number of strategies were employed to support and take full advantage of the integrated design process, such as direct tutorial and mentoring, consideration of the requirements of the various disciplines, multi-disciplinary design charrettes, and collaboration with outside consultants and industry professionals.

Numerous design charrettes were held following the submission of the proposal to Solar Decathlon organizers. The goal of the charrettes was to develop a strong understanding of the project's design challenges and further explore the proposal.

The charrettes gathered students from various disciplines, faculty advisors, industry consultants, and recent graduates. They enabled the multi-disciplinary team to collaborate and refine the housing concept. The outcome of these charrettes was a more solid and convincing project design.

In addition to the charrettes, university courses were shaped based on the *Lumen | Essence* project proposal. Various design exercises were undertaken by Université de Montréal and McGill University students to provide the team with lessons learned and further options. Some of these exercises focused on particular aspects of the project, such as natural lighting and ventilation. Simultaneously, directed study courses at these two institutions centred on relevant topics, including passive energy systems, materials, assembly and transportation, day-lighting, and urban planning for solar design. These courses became the basis for further design charrettes.

Meanwhile, students from École de Technologie Supérieure conducted further research on construction, assembly, and transportation issues; structural and construction systems; and building performance (e.g. interior thermal, humidity, and air quality control).

Over the course of the design process, a series of events and presentations were held to promote the *Lumen | Essence* house. Project management and communications and marketing students attended trade shows and conventions, team presentations, media events, a project launch press conference, and the Solar Decathlon competition. An important aspect of the Solar Decathlon involved communicating clear and consistent messages about the project to a large audience via a web site and presentations.

Building and Operation of the Home

At the building stage, the administrative council that was once limited to academic representatives was expanded to include major sponsors and partners as well as external construction management and communications consultants. The team initiated relationships and negotiated with various trades people, suppliers, and other industry professionals. These new members contributed valuable expertise and knowledge to the team.

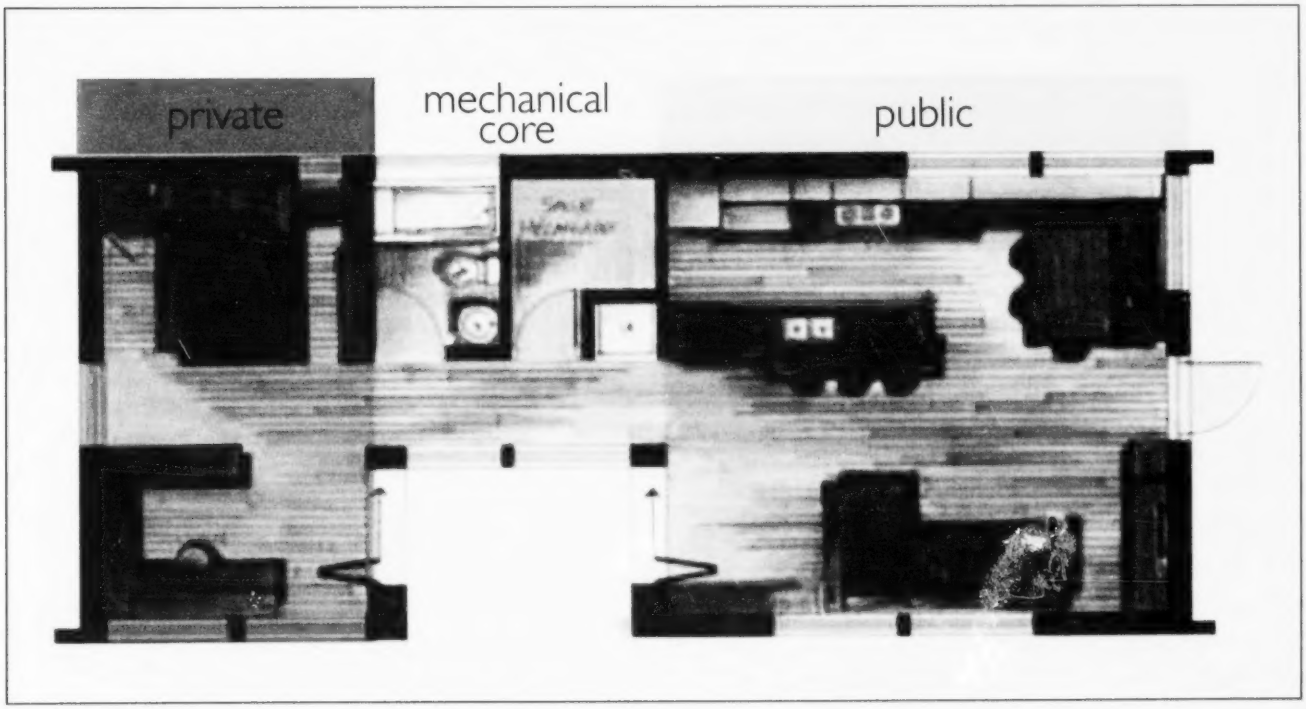
Assembly of the home in the design-build studio/workshop helped finalize construction details and provided Team Montréal with an opportunity to construct (and disassemble). This was accomplished using a shop drawing format and through consultation with suppliers, students, professors, other sponsors, and project/construction management consultants.

The house was transported to Washington in two trucks and trailers and one low bed. Transportation services were provided by SGT, a company specializing in transborder long hauls. The team worked around the clock in the days leading up to the competition to ensure construction advanced rapidly. Certain parts of the structure were intentionally left exposed in order to show visitors the workings of the home. During the competition, the team worked around the clock to ensure all systems functioned optimally, monitor the home's performance, and further strategize on how to score the highest number of points in each category.

About the *Lumen | Essence* House

The *Lumen | Essence* house is an 800 square foot open concept bungalow with 560 square feet of living space. It features a highly insulated, innovative structural support system with an angled roof designed to cope with a harsh, northern climate. The house is divided into three separate areas (Figure 2): the living, dining and kitchen area (Figure 3); the bedroom and office (Figure 4); and the mechanical room. The mechanical room is located at the core of the home, accentuating its central role as the main energy generator for the house.

Figure 2 Floor plan



The house was built using an innovative, modular light steel construction system called BONE Structure™ from Simple Concept Inc. A system of brackets allows walls, floor and ceiling modules to be "clipped" to the structural elements of the home. The system also favours a flexible open-concept plan, as it reduces the need for supporting walls and columns.

Figure 3 The Kitchen

The benefits of the BONE Structure™ system include quick assembly, ease of transportation, and minimal construction waste. This system was selected chiefly for its straightforward fabrication and disassembly. It enabled the home to be assembled first in Montreal, and then disassembled and moved to Washington, where it was reassembled.

A variety of sustainable materials were used to bring the *Lumen | Essence* concept to life. A soy-based polyurethane foam insulation, consisting of recycled plastics and soybean oil, was sprayed to seal and insulate the exterior of the structure. This naturally sourced product offers ultra-efficient thermal resistance as well as an air and vapour barrier. It is also mould- and fungi-growth resistant. It ensures that the house remains warm in the winter and cool in the summer and prevents drafts.

The home's interior courtyard uses the Solera wall system, which is composed of a layer of honeycomb insulation sandwiched between two light-diffusing screens and two panes of glass. The honeycomb cells in the insulation are perpendicular to the glass panes thus creating dead space. This prevents air convection between the panes, diminishing heat loss in the winter and heat gain in the summer.

The placement and size of windows was determined using EcoTect and Radiance computer simulations to optimize day-lighting. Triple-glazed, low, argon-filled windows from Alumilex minimize heat losses and gains and feature automated shading to control overheating in the summer.

Kiln-baked birch wood cladding was used as an external finish, creating an attractive contrast with the metallic shade of the photovoltaic array and the bright yellow finish used for the mechanical block. The wood cladding is treated at very high temperatures, which greatly reduces water content, thus increasing its durability and minimizes the need for maintenance after it is stained.

Aluminum cladding strips, provided by Stairco, were applied to the east- and west-facing façades, lining the home. The mechanical block was covered with unique, yellow aluminum siding from Vicwest and was custom-designed for the project, further emphasizing the "heart" of the home.

The interior walls, composed of NuGreen formaldehyde-free chipboard with fibreglass textile, were finished with water-based paint.

A green wall was mounted on the south-facing façade of the home to capture water during a rainfall, prevent the "heat island effect" experienced in an urban context, and provide

Figure 4 The Bedroom

an additional insulating mass. It was developed by the Montreal-based company Envirozone. The home also includes a green, or vegetated, roof on the north side of the house.

The home automation system, designed by the students, provides real-time user information on energy consumption, production forecasts, accumulated energy reserves in the batteries and snapshots of consumption and production of electricity. Energy management incorporates weather forecasts, automatic shade control and lighting management as integral components of the automation system. The system also makes recommendations for improving energy management and is designed as a tool to raise occupant awareness of electricity consumption.

Competition Results

The teams were tasked with designing and building energy-efficient homes that are powered exclusively by the sun. In addition, the homes had to be attractive, easy to live in, and capable of powering an electric vehicle. Specifically, the homes were evaluated based on the following criteria ("contests"):

1. Architecture (200 points)
2. Engineering (150 points)
3. Market Viability (150 points)
4. Communications (100 points)
5. Comfort Zone (100 points)
6. Appliances (100 points)
7. Hot Water (100 points)
8. Lighting (100 points)
9. Energy Balance (100 points)
10. Getting Around (100 points)

The scores were based on performance measurements, completion of tasks or by the evaluation of jurors who assessed the less tangible aspects of the home. Certain categories were scored using a combination of these methods.

Team Montréal placed an impressive 8th overall at the Solar Decathlon competition. Notably, the team achieved 2nd place in the Comfort contest, 4th in Engineering, 5th in Lighting, and 6th in Architecture.

Germany's Technische Universität Darmstadt ranked first overall, while second and third place went to the U.S.'s University of Maryland and Santa Clara University, respectively.

Conclusion

The Solar Decathlon competition presents a unique opportunity for the engineers, architects, researchers, building professionals, and homeowners of tomorrow to innovate, showcase their skills, and raise awareness of solar-powered housing. Following the competition, the *Lumen | Essence* house was transported back to Canada and became a permanent part of a renewable energies exhibit at the Biosphere Environment Museum in Montreal.

For more information on the Solar Decathlon event and the winners, visit: **www.solardecathlon.org**. For more information on Team Montréal and its principal sponsor, visit: **www.SolarMontreal.ca** and **www.BoneStructure.ca**.

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Housing Research at CMHC

Under Part IX of the ***National Housing Act***, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

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